Potato Productivity and its Determinants: A Case Study in Sonitpur District, Assam

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Abstract

In the predominantly agriculture based economy of Assam, Potato in recent years has emerged as an important commercial crop. This paper examines the determinants of potato productivity from a case study conducted in Sonitpur district of the state. Understanding on the determinants is important as farm productivity helps to augment income of the farm households as well as employment opportunity. The results show that in the study area net income of the farmers is positively related to productivity of the crop and thus indicates the importance of raising productivity. The relationship between inputs and output is estimated by applying Cobb-Douglas production function. The results show positive influence of certain inputs in case of this crop. Certain issues which need attention are inadequate availability of HYV seeds, high costs of inputs, lack of credit and storage facilities.

I. Introduction

Potato is one of the important crops which contribute to food and nutritional security. This tuber crop also has industrial and medicinal uses. As potato has high demand and market in developing countries like India, cultivation of this crop plays an important role to ensure returns to the cash starved rural households. This crop is not indigenous to India, but penetrated as a consequence of the colonial expansion of European countries. It was introduced in the country by early 17th century probably by British missionaries or Portuguese traders.

Potato now has emerged as the foremost important crop in India after rice, wheat and maize; and the country has emerged as the second largest producer of potato in the world. In 2010-11, India produced 42.34 million tonnes from 1.86 million hectares of cultivation with an average yield of 22720 kg/ha. In India, during 2005-06 the share

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of area under potato was 0.75 per cent of the gross cropped areas which rose to 0.79 per cent in 2010-11 (Economic Survey, 2011-12). Potato is an important crop in the north eastern region of India too. Agro-climatically the region is highly suitable for the cultivation of *tuber crops* (potato, sweet potato, carrot etc.) and the people in the hill areas of the region are accustomed of growing these crops. Tuber crops are not only cultivated in the hilly areas of the region but also in the plains of Assam and Tripura. These crops do not require much attention and no serious disease or insect attack are observed. These crops often get preference as risk aversion crops in this difficult region having shortage of food grains supply. Among the tuber crops, potato is grown in all the states of the region. The northeast region accounts for 6.6 per cent of the total area under potato in the country.[1]

Among the states of the north east region, Assam with a share of 4.7 per cent area and 1.6 per cent of total production in India occupies prominence. In Assam, total production of potato was 975.27 thousand tonnes and area under it was 99.77 thousand hectares with a yield of 9770 kg/ha in 2012-13 (GoA, 2013-14). The average yield of potato in the state however is very low compared to average of the country (22724kg/ha during 2010-11), and demands an improvement. NITI *Ayog* also identifies increasing agricultural productivity as one of the ways to improve the income and living conditions of farm households (Chandrasekhar and Mehrotra, 2016). As there are not ample literature to study the developments of this crop in the state, this paper is an attempt to understand the nature of potato cultivation, trend in productivity and impact on farm income and employment opportunities taking few production pockets of Sonitpur district of Assam as an area of study.

Sonitpur district now occupies a prominent space in potato production in Assam with 6.8 per cent share of total potato production during 2012-13. Newspaper reportage[2] indicates how little known places of the district have come to prominence with emergence of hundreds of potato farmers. For example in a small place called Gingia, near Biswanath Chariali town, farmers are now cultivating potatoes on plots which ranges from 2 to more than 50 hectares.

II. Approach of the Paper

Data for this paper are derived from a primary survey. In addition to the primary data, secondary data from various government sources are used to supplement the analyses. A questionnaire was designed to collect information on area sown, output, inputs used, cost of inputs, quantity sold and prices fetched. The field data was collected through a multi-stage random sampling. In the first stage, four development blocks namely, Sakomotha, Baghmara, Biswanath and Naduar of Sonitpur district were selected on the basis of distance from the district headquarter. From each block two villages were selected purposefully on the basis of distance from the block headquarters, with one

[1] MoSPI, Government of India, 2009-10.

[2] Potato cultivation ushering green revolution, The Assam Tribune, April 11, 2013

village located near the block headquarters and the other at a distance. In each village 15 farmers were randomly selected for interaction.

The Cobb-Douglas production function is applied to estimate the elasticity of output with respect to the inputs. The Cobb-Douglas type production function has been widely used in analysis of agricultural production for its simplicity and reliability (Dutta, 2003).

III. Cropping Pattern and Potato Production in Assam

An analysis of cropping pattern in the State revealed that since the turn of the century the pattern has not changed significantly. In 2001-02, food grains accounted for 79.4 per cent of the cropped area which marginally declined to 77.9 per cent in 2013-14. This was mainly due to fall in area under rice and wheat by more than 1 percentage point. The area under rice fell from73.3 per cent in 2001-02 to 72.0 per cent in 2013-14. During the same period area under wheat fell from 2.08 per cent to 0.89 per cent. But the share of area under maize and pulses increased marginally during this period (Table 1).

Table 1: Changes in cropping pattern in Assam (Area is in %)

Crops	2001-02	2013-14
Rice	73.32	72.03
Wheat	2.08	0.89
Maize	0.58	0.69
Pulses	3.41	4.32
Total Food grains	**79.39**	**77.93**
Oilseeds	9.25	9.35
Potato	2.31	2.82
Onion	0.20	0.20
Fruits & vegetables	4.88	5.90
Other crops	3.96	3.80
Total Non-Food grains	**20.61**	**22.07**

Source: Statistical Handbooks Assam (2004; 2015)

During the same period, the area under non-food crops increased marginally from 20.6 per cent to 22.1 per cent. This was on account of increase in the share of area under fruits and vegetables by more than 1 percentage point and increase in area under potato. The share of area under potato increased from 2.3 per cent in 2001-02 to 2.8 per cent in 2013-14. While the share of area under oilseeds marginally improved, the share of area under onion remained stagnant. The share of area under other cash crops declined marginally. An analysis of cropping pattern indicates that over the years it is changing gradually in favour of cash crops.

Assam accounted for 2.02 per cent of total food grains production in the country during 2011-12. Among the food grains, the state contributed 4.84 per cent of rice

production in the country (GoA, 2013-14). During the same year, the state accounted for 1.65 per cent of potato production in the country. The share of rice and potato in total production of the country shows importance of the state in terms of agricultural production. However, the poor productivity of the crops in the state is an area of concern[3]. For instance, yield of rice in Assam was 1780 kg/ha in 2011-12, lower than the country average of 2393 kg/ha. The yield of wheat was 1147 kg/ha which was much lower than the country average of 3177 kg/ha (Basic Statistics of North Eastern Region, 2015). All these imply that that state requires attention to raise agriculture productivity. This paper tries to understand the determinants of agriculture productivity taking potato as a case.

Growth of area, production and yield of Potato

An analysis of growth of area, production and yield shows that area under potato cultivation in Assam has increased from 81 thousand hectares in 2000-01 to 105 thousand hectares in 2012-13. The compound annual rate of growth (CAGR) of area was 2 per cent during the period 2000-01 to 2012-13. During the period 2000-01 to 2006-07, however there was fall in area under potato. The CARG of area during this period was (-) 1.4 per cent; but during the period 2007-08 to 2012-13 the area under potato registered a high CAGR of 6.9 per cent (table 2).

Table 2: Trend and growth of area, production and yield of potato in Assam

Year	Area	Production	Yield
2000-01	81	677	8254
2001-02	80	621	7752
2002-03	75	590	7815
2003-04	78	543	6972
2004-05	73	589	8058
2005-06	70	354	5079
2006-07	78	505	6493
2007-08	75	521	6926
2008-09	78	516	6585
2009-10	83	600	7263
2010-11	85	658	7735
2011-12	98	683	6978
2012-13	105	806	7675
CARG (2000-01 to 2012-13)	2.00	1.3	-0.4
CARG (2000-01 to 2006-07)	-1.4	-6.9	-5.4
CARG (2007-08 to 2012-13)	6.9	9.2	2.3

Note: Area in '000 Hectare, Production in '000 Tonnes & Yield in Kg/Hectare
Source: Statistical Handbook of Assam (2001-02 to 2013-14)

[3] There could be several explanations for poor agriculture productivity in Assam. Apart from the institutional factors of assurance of good quality seeds, provisioning of irrigation etc., repeated waves of floods and subsequent externalities of erosion and sand deposition are also the causes.

During the period 2000-01 to 2012-13 total production of potato increased from 677 thousand tonnes to 806 thousand tonnes. The CARG of potato production during this period was 1.3 per cent. The potato production during the period 2000-01 to 2006-07, however declined sharply with an annual decline of (-) 6.7 per cent; but, during the period 2007-08 to 2012-13 production of potato in the state increased sharply at an annual rate of 9.2 per cent[4]. It was observed that during the period 2000-01 to 2012-13 productivity of potato in the state declined from 8254 kg/ha in 2000-01 to 7675 kg/ha hectare in 2012-13 at an annual rate of (-0.4 percent). This fall in productivity during the period 2000-01 to 2006-07, however was much sharper at (-) 5.4 per cent. Later in the period 2007-08 to 2012-13, potato productivity increased significantly with CARG of 2.3 per cent.

The decline in productivity of potato during the entire period is a cause of concern and calls for attention. There is need to identify the causes and make necessary efforts to improve productivity and ensure improve well-being of the farmers.

IV. Input Use, Costs and Returns

An attempt was made to measure the quantity of various inputs used in production of potato and estimate the costs and returns assuming the role of inputs in raising productivity of the crop. The principle inputs used in potato production in the study area are; seeds (HYV as well as local variety), chemical fertilisers, organic manure (cow dung and oil cake), labour, machinery (tractor and sprayer) and irrigation (pump sets with diesel). The farmers are using both HYV (*Punjab Pokhraj*, *Punjab jyoti*, *Mohendra Jyoti*, *Super S1)* as well as local seeds. But because of high cost of HYV seeds, farmers also found using local variety of seeds[5]. Field visit revealed high difference of average prices of HYV (Rs. 62/kg) and local seeds (Rs. 20/kg). Regarding fertiliser, farmers were found to be using mainly Di Amino Phosphate (DAP)[6]. Along with DAP they were using Urea, Potash and Super in limited quantity. The price of DAP was Rs. 27/ kg, Urea Rs. 9/ kg, Potash Rs. 18/kg and Super Phosphate at Rs. 9/kg. Farmers were found to be using enough quantity of locally available cow dung and oil cake. The estimated quantity of seed, fertiliser and manure used per hectare is presented in table 3.

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[4] The potato production in Assam declined during the period 2001-06 due to fall in both area and yield. The fall as informed during the field visit was due to non-availability of quality seed and lack of scientific knowledge to cultivate potato. After 2006 the situation has changed because of incorporation of technology and state support on various fronts. This issue require a detailed study.

[5] During the field visit it was found that most of the farmer in Biswanath and Sakomatha block were using HYV seed and farmers in other two blocks were using more of local variety as majority of farmers were small and marginal and could not afford HYV seed.

[6] DAP is considered to be a balanced fertiliser. DAP or diammonium phosphate is a widely applied phosphorous fertiliser, and its use has been dramatically increasing.

Table 3: Quantity of seed, fertiliser and manure used by the farmers

Block	Seed (in kg/hectare)	Fertiliser kg/hectare	Manure in kg/hectare
Baghmara	2050	400	673
Biswanath	1950	300	2730
Naduar	2038	320	1417
Sakomotha	2100	240	2247

Source: Field Survey, 2015

Relatively lesser quantity of seed was used per hectare in Biswanath block. This is because to the fact that farmers in this block used HYV seed in greater proportion than other blocks. The quantity of HYV seed required in a given area is reported to be less than the local variety. Use of chemical fertiliser used per hectare was the highest in Baghmara block (400 kg per hectare) and lowest in Sakomotha block (240 kg per hectare) and it appeared that low use is complemented by use of organic manure. Overall it appears that use of locally available organic manure is the priority among the farmers. Field survey revealed that the high use of manure in Biswanath and Sakomotha blocks was mainly due to the availability factor; this was not the case in other two blocks. On the other hand there was less variation in the use of chemical fertiliser in the study blocks. Here emerge two issues. One, along with the availability factor of manure, there is need to test the conditions of soil to assess the quantum of manure or fertiliser required to be supplemented. Two, variation in potato productivity would indicate that there is need to assess the soil conditions and accordingly make provision to nourish the soil. In case there is no significant difference in productivity, looking at the variations on the quantum of chemical fertiliser and organic manure applied, it would imply that farmers in the study area are rational in application. This however is not the case as it appears from the field data that high potato productivity in Biswanath and Sakomotha is largely correlated to use of manure in higher quantum; and in Baghmara and Naduar block limited use of fertiliser and manure has affected potato productivity. Moreover, one area requires exploration to what extent price of fertilisers and capability factor of the farmers inhabit application.

Potato crop is affected by fungal disease called 'blight'. It is also affected by various insects. Farmers in the study area use primarily Indofil M-45 and Cutter Pillar to control diseases and infections. The price of Indofil M-45 was Rs. 440 per kg and the price of Cutter pillar was Rs. 800 per litre. The quantity of chemical used per hectare is given in the table 4.

Table 4: Quantity of chemical used per hectare by the farmers

Block	Indofil M-45 (in kg/hectare)	Cutter Pillar(in litre/hectare)
Baghmara	5.33	1.94
Biswanath	6.93	1.97
Naduar	4.64	1.85
Sakomotha	8.83	7.33

Source: Field Survey, 2015

The table 4 shows that there are variations in use of Indofil M-45 used per hectare in the study blocks. Field interaction revealed the variations is due to capability factor to purchase the chemicals as well as limited availability. Other inputs used in potato production were labour, machinery and irrigation. Labour use in potato production has been measured in terms of number of labour days. Machinery used has also been measured in terms of number of days used. Irrigation used was measured in terms of hours the pumps run for providing water. The level of use of these inputs is presented in the table 5.

Table 5: Labour, machinery and irrigation used by the farmers

Blocks	Labour (in days/hectare)	Machinery (in days/hectare)	Irrigation (in hours/hectare)
Baghmara	150	10	20
Biswanath	147	11	19.5
Naduar	168	13	18
Sakomotha	140	10	18

Source: Field Survey, 2015

Labour use data indicate that cultivation in one hectare provide opportunity for one person to get engaged for half of the year. Man days spent in other inputs indicate that potato cultivation in the study area is labour intensive. It is however noticed that intensity of labour use (Table 5) and productivity of potato (Table 6) have no association in the study area. All the surveyed households were found using privately procured boring and electric pumps to supply water in their fields. Irrigation is necessary as potato in the area is grown only during the winter.

Table 6: Yield rate of potato in the surveyed farms

Blocks	Yield (in kg/hectare)
Biswanath	25600
Sakomotha	20150
Baghmara	19700
Naduar	18775

Source: Field Survey, 2015

The survey found that yield of potato in the study area is much higher than the state average and comparable to the country average. The high yield rate of potato in Biswanath and Sakomotha blocks can be attributed to extensive use of organic manure. On the other hand, in case of non-availability of organic manure in adequate quantity, the farmers supplement the requirements with chemical fertiliser. However, the price of chemical fertiliser price acts as an impediment, as reported by the farm households. The size class of operational holdings of the sample potato farmers indicate that that most of the farmers in Biswanath and Sukomotha blocks have medium (4 to 10 ha of size) and large holdings (more than 10 ha). In Biswanath block two third of the farmers have medium and large holdings and in Sakomotha block 60 per cent of the farmers have medium and large holdings. On the other hand in Bagmara and Naduar blocks 43

and 37 per cent farmers respectively have medium and large holdings. It appears that larger size of holdings help the farmers to intensify inputs use and obtain high yield. The yield rate of potato was found to increase with increase in the size of holdings (Table 7).

Table 7: Yield rate of potato by size of holdings

Size of holdings (in Hectares)	Yield (in Kg/hectare)
Small (1-2 hectares)	19800
Semi-medium (2-4 hectares)	20113
Medium (4-10 hectares)	20781
Large (10 and above hectares)	21053

Source: Field Survey, 2015

The farmers in the study area produce potato primarily for market and sell through middlemen at wholesale price. It was estimated that about 95 per cent of produce goes to the market. The average price of potato received by the farmers varied from Rs. 9.5 in Naduar block to Rs. 7.6 in Sakomotha block during the time of field survey[7] (Table 8).

Table 8: Gross revenue per hectare

Blocks	Average price per kg (in Rs)	Quantity sold per hectare (in kg)	Revenue per hectare (in Rs)
Biswanath	7.91	23177	183326
Naduar	9.53	18156	173029
Baghmara	8.07	19267	155483
Sakomotha	7.63	19648	149913

Source: Field Survey, 2015

The gross revenue per hectare is dependent on yield rate and price[8]. The cost of production per hectare of potato helps to estimate the net revenue. Table 9 indicate that there is less variation in input costs across the study blocks, but there is productivity led variations in net revenue. We also find indication that higher yield is associated with use of fertiliser and manure.

[7] Price of potato varied from block to block mainly because of different harvesting time. In Naduar and Bagmara blocks potato was harvested early in the month of October and November. So they get high price due to limited supply in the market during that period. In Biswanath block potato is harvested late so they get lesser price.

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Table 9: Net revenue per hectare

Blocks	Total revenue per hectare (in Rs.)	Total cost per hectare (in Rs.)	Net Revenue per hectare (in Rs.)
Biswanath	183326	130155	53171
Naduar	173029	120838	52191
Baghmara	155483	117835	37648
Sakomotha	149913	114222	35691
All Total	165438	120763	44675

Source: Field Survey, 2015

The table 9 reveals that net return per hectare of potato cultivation varies with the yield (the case of Biswanath block) and the price received at market (Naduar block). The costs of production on the other hand vary with the amount of inputs used. Overall it reveals that to enhance the income of the farmers there is need to raise the yield and have a system to ensure remunerative price for the crop[9].

V. Determinants of Potato Productivity

An analysis of determinants of potato productivity is important to understand relative importance of various inputs. The farmers in study area use seeds, organic manure, chemical fertilisers,, labour, machineries as inputs to produce potato. This analysis however uses only the variables indicated in Table 10 to understand the determinists.

Specification of the model

The Cobb- Douglas type production function is used to estimate the relationship output and inputs used. The function is specified as below:

$Y = A.F^{b1}.M^{b2}.MU^{b3}.SC^{b4}.FS^{b5}$
Where,

Y = Output per hectare (kg), F = chemical fertiliser per hectare (in kg), M = manure per hectare (in kg), MU = machinery use per hectare (in days), SC = seed cost per hectare (in Rupees) and FS = farm size (in hectare). 'A' stands for technological parameters.

The Log-Linear form of the above function may be written as:

$$\text{Log } Y = a + b_1 \log F + b_2 \log M + b_3 \log MU + b_4 \log SC + b_5 \log FS + \mu \quad \ldots\ldots\ldots (1)$$

[9] There are four regulated markets for agriculture procurement in the district. A review of data on arrival of crops in these regulated markets would reveal that though prices appear to be remunerative (for example potato price reached a maxima of Rs. 1600/ quintal on 12 December 2016 and a minimum of Rs. 800/ quintal during the period November 1, 2016 to January 15, 2017; the quantum of potato arrived were meagre at 15 quintal and 8 quintal on respective dates. This was a case of regulated market of Dhekiajuli (Data derived from agmark.gov.in) There is scope to look at this issue in detail.

Here, μ denotes the disturbance term that is assumed to follow the classical assumptions of OLS estimation. The intercept term captures the effect of excluded variables. The regression coefficients represent output elasticity with respect to the explanatory variables.

Results and Discussion

Initially, the regression was run with seven variables. But correlation between the variables labour and machinery was found to be positive and significant. Similarly, there was a positive correlation between chemical cost and fertilisers. Hence, to avoid multicollinearity, variables labour and chemical cost were removed and finally five explanatory variables were considered for the analysis. The result of the regression analysis in equation 1 is presented in table 10.

Table 10: Regression result for determinants of potato productivity

Dependent Variable: Log of output (Y) per hectare

Independent Variables	**Co-efficient**	**SE**	**t-value**	**p-value**
Log Fertiliser (F)	0.35	0.122	2.905***	0.004
Log Manure (M)	0.23	0.038	6.059***	0.00
Log Machinery Use (MU)	0.29	0.124	2.405**	0.018
Log Seed Cost (SC)	0.076	0.051	1.503	0.136
Log Farm Size (FS)	0.037	0.039	0.952	0.343
Constant	3.89	1.134	3.434	0.001
R-Square	0.35			
Adjusted R Square	0.32			

Note: *** and ** indicate significant at 1 and 5 per cent level respectively.

The results show that the coefficients of manure and fertiliser are positive and significant level. However the output was found to be more elastic to fertiliser than manure. The coefficient of machinery is also positive and significant. The coefficients of seed cost and farm size are also positive but not statistically significant at any critical level. Thus, it is seen that, among the five explanatory variables output is more elastic to fertiliser followed by manure and machinery use. The relationship between farm size and productivity in case of potato was positive but not significant. Hence, positive relationship between farm size and productivity could not be confirmed. The sum of the coefficient in Cobb-Douglas production function indicates returns to scale. The sum of the coefficient was found to be 0.98 which indicated decreasing returns to scale in potato production.

Thus, it can be concluded that potato production is highly elastic to inputs like fertiliser, manure and machinery. Application of seeds and farm size though were not found to be significant at any critical level its' positive co-efficient indicates that it has a direct relation with level of output of potato. It can be suggested to encourage judicious use of chemical fertilisers and organic manure along with HYV seed to raise productivity of potato.

VI. Conclusion

An assessment on the condition of the soil and subsequent requirement of inputs for nourishment appear as prime tasks to sustain agriculture productivity in the flood ravaged state of Assam. In this state food and nutritional security to a large extent is being ensured by cultivation of *Rabi* crops. In this context access and provisioning of organic manure and fertiliser, quality seeds and irrigation are appearing as prime contributing factors of productivity. The access factor of inputs also leads to the discussion on agriculture credit and, input and farm subsidy to attain larger goal of sustainable rural livelihood.

As revealed from the field survey there is production boom in the study pockets. Here the concerns are to prevent post-harvest losses, ensure storage facilities[10] so that remunerative price for the farmers can be ensured. One positive indication inferred from the field survey is preference for the use of organic manure over chemical fertiliser. This is to an extent being ensured by the availability factor at village level. Concern is also there to address the negative externalities of chemicals in rural areas. Steps are also needed for ensuring a direct link between farmers and remunerative markets to sustain the enthusiasm of the farmers.

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[10] Assam State Agriculture Marketing Board now has 5 operational cold storages (none in Sonitpur district) with altogether 6500 MT capacity. It is reported that disruption of power supply hits these existing cold storage facilities. There are two more under construction with a proposed provisioning of 10000 MT. Moreover, in the state there about 60 private cold storages with a capacity of 100,000 MT in the state, largely caters to store 20-25 lakh MT of potato imported to Assam annually (The Telegraph, April 13, 2015). In the study locality of Gingia, near Biswanath there is a cold storage primarily for potato; but reportedly inadequate to cater the needs.

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